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Materials and Processes for Renewable Energy Technologies

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This collection of papers is dedicated to the topic "Materials and Processes for Renewable Energy Technologies". The focus is on concentrated solar energy, which provides a source of clean, non-polluting, high-temperature heat for power and fuels production. Current technologies are based on solar receivers that usually operate below 500°C, coupled to steam-based Rankine cycles for power generation at 20% peak efficiency. The next generation of technologies will allow for surpassing 1000°C and enable higher efficiencies via Brayton–Rankine combined cycles. Olivares et al.[1] present a thermogravimetric study on promising high-temperature-resistant alloys for application in solar air receivers coupled to gas turbines.

Solar thermochemical approaches to splitting CO_2 and H_2O inherently operate at high temperatures and use the entire solar spectrum, and as such, they provide a thermodynamically favorable path to solar fuels production. Several authors investigate two-step redox cycles, encompassing the solar thermal reduction of a metal oxide followed by its re-oxidation with H_2O and CO_2 for H_2 and CO generation. Allen et al.[2,3] examine doped ferrite as redox material and analyze its reaction kinetics. Ceria emerges as another attractive redox candidate because of its high oxygen ion conductivity. Ganesan et al.[4] determine the optical properties of ceria when exposed to concentrated solar radiation. Suter and Haussener[5] present a tomography-based methodology to characterize and optimize porous reticulated ceramic materials used in solar power and fuel applications.

Solar concentrating technologies offer round-the-clock dispatchability of heat and power through the integration of thermal storage and/or hybridization. There is an opportunity for the minerals processing industry to take advantage of these developments and use the same solar concentrating infrastructure as a direct heat source at high temperatures. The candidate processes are the production of metals (e.g., zinc, magnesium, aluminum, and silicon) from their oxide ores by carbothermal reductions. These processes are highly endothermic and are characterized by their concomitant vast emissions of greenhouse gases (GHGs) and other pollutants. The use of solar process heat integrated with thermal storage offers unique potential advantages for GHG avoidance in extractive metallurgical processes. Eglinton et al.[6] assess this potential for the Australian minerals industry. Vishnevetsky et al.[7] describe exploratory experimental studies on the production of aluminum by carbothermal reduction of alumina at vacuum pressures, enabling its vacuum distillation while bypassing the formation of undesired by-products. Tzouganatos et al.[8] experimentally demonstrate the recycling of zinc by clinkering of Waelz oxide and by its carbothermal reduction using a packed-bed reactor driven by concentrated solar energy. Finally, Perruchoud and Fischer[9] describe the production of upgraded metallurgical silicon, which is the preferred feedstock for the preparation of solar grade silicon for photovoltaic cells.

These original papers indicate favorable long-term potential of materials and processes for solar technologies, warranting further research, development, and large-scale demonstration.

Aldo Steinfeld is the guest editor for the Energy Committee, a joint committee of the TMS Extraction and Process Division and the TMS Light Metals Division; and the coordinator of the topic Materials and Processes for Renewable Energy Technologies in this issue.

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